School of Economic Sciences

Working Paper Series
WP 2008-5

What does Initial Farm Size Imply about Growth and Diversification?

By

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2008

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The authors gratefully acknowledge the significant contributions of the anonymous reviewers to the quality of this paper. This project was supported by the Washington Agricultural Research Center, the USDA Cooperative State Research, Education and Extension Service Hatch grant WPN000275, and the USDA Economic Research Service.

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Abstract

Recent consolidation in agriculture has shifted production toward fewer but larger farms, reshaping business relationships between farmers, processors, input suppliers, and local communities. We analyze growth and diversification of U.S. corn, wheat, apple, and beef, farms by examining longitudinal changes in ten size cohorts through three successive censuses. We fail to reject Gibrat's law in apple and wheat industries and the mean reversion hypothesis in beef and corn industries. Apple and wheat farms diversify over time. Findings suggest that scale economies diminish for large farms across all four industries and scope economies dominate scale economies for large apple and wheat farms.

Key words: firm growth, diversification, scale economies, scope economies, Gibrat's law, longitudinal data

JEL classification: Q12

What does Initial Farm Size Imply About Growth and Diversification?

Scale and scope economies at the farm level are among the important driving forces behind the rapid structural change in U.S. agricultural industries. Agricultural production is becoming dominated by large, highly integrated farms that adopt new technologies and business practices to exploit these economies (Hoppe et al. 2007). One relevant public concern is just how far economies of scale and/or scope will push this sector. If the largest food production firms experience economies of scale and scope and if those economies do not dissipate, we would expect movement toward smaller and smaller numbers of firms. If that movement were to continue unabated, it is conceivable that the perfectly competitive nature of some agricultural production industries could eventually disappear, resulting in potentially higher prices, less consumer and total welfare, and a threat to the long-term economic viability of the family farm. Under this setting, regulatory oversight may be required to ensure a competitive outcome with few farms. The agricultural production sector is currently so far from consolidating ownership under a small number of firms that competitive production is still regarded as dominant in agriculture for all but a few niche markets.

Four major agricultural industries are chosen for the purpose of studying scale and scope economies. Corn, wheat, apple, and beef industries represent major sources of U.S. agricultural production. Corn and wheat are the two largest U.S. grain crops, both in terms of value of production and planted acreage. Respectively, they accounted for 75% and 17% of total value of grain production and 54% and 36% of total area planted to grains in 2006. Apples rank second

after grapes in total value of fruit production and planted fruit acreage, accounting for 21% of the value of total fruit production and 18% of total area planted to fruit in 2006. Beef represents the largest segment of the U.S. livestock sector. Sale of cattle and calves accounted for 73% of total value of production of meat animals in 2006 (USDA 2007).

Between 1987 and 2002, the total number of farms in each of these industries fell while the number of farms in the largest census farm category grew (see Figure 1). The relative growth in number of larger farms was much greater in the corn and wheat industries than in the apple and beef industries. Total production rose in the corn and beef industries while production dropped in the wheat and apple industries. However, the drop in wheat production was less than the relative decline in total number of farms in the wheat industry so this industry also became more concentrated. Production concentration was greater in the corn and beef industries than in the wheat industry, and the evidence of increased concentration in the apple industry was mixed.

The rapid changes in these industries suggest several important empirical research questions and testable hypotheses with regard to firm and industry growth that could have implications for public and private decision making. For example, profit-maximizing, risk neutral, price-taking firms are expected to grow if they can exploit scale and/or scope economies. Scale economies exist if the firm experiences decreasing average cost as output increases, while scope economies exist if the average total cost of production decreases as a result of increasing the number of goods produced.

While there is considerable evidence that scale and scope economies apply generally to agricultural industries, whether they apply to the largest farms is an open empirical question. The empirical evidence is inconclusive and varies with industry of interest and approach used to examine the evidence (e.g., Mulik, Taylor, and Koo 2005; Just, Mitra, and Netanyahu 2005;

Morrison-Paul, Nehring, and Banker 2004; Helmers and Atwood 2003; Mafoua 2002; Morrison-Paul 2001; Ollinger, MacDonald, and Madison 2000; Ben-Belhassen and Womack 2000). For example, even two very recent studies (Skolrud et al. 2007; Mosheim and Lovell 2006) found contradictory evidence about scale economies in the dairy industry. The former found evidence of non-diminishing scale economies for the largest decile of dairy farms while the latter found constant or declining returns to scale for larger farms. Our research expands the analysis of scale and scope economies in the context of industry consolidation for the corn, wheat, apple, and beef industries.

The purpose of this paper is to learn about growth and diversification trends within size cohorts for the four industries and compare them to those of the dairy industry. It contributes essential missing links in understanding how structural change is occurring at the firm level in these industries. Although it does not address causation, the paper creates an informational base that is particularly relevant for econometric analysis of causal factors. For example, if evidence of scale diseconomies were found in an industry, it would suggest that other forces, e.g., human capital, business/family life cycle, value chain, government policies (Gray and Boehlje 2007; Hoppe et al. 2007), must be operating to drive consolidation.

We extend the analysis used by Skolrud et al. (2007) for the dairy industry to determine whether cost economies are evident in the U.S. corn, wheat, apple, and beef industries. We seek answers to three research questions that apply to incumbents in all four industries. First, do the largest farms grow at least as rapidly as medium-sized farms? If they grow less rapidly, it would suggest that convergence toward an equilibrium size is occurring even if that equilibrium size has not been observed yet. On the other hand, if the largest farms grow at least as fast as the medium-sized ones, we must conclude that farms are not yet approaching an equilibrium size.

Second, do farms become more diversified over time? If they do, it would provide inferential evidence of increasing economies of scope.[1] Third, if they do become more diversified over time, do the largest farms diversify more rapidly than medium-sized farms? If they diversify less rapidly, it would suggest that a change in the relative importance of scale and scope economies could cause medium-sized farms to grow the fastest in the future even if the largest farms currently grow most rapidly. If, however, the answer to all three questions is yes, then even without further analysis, we would conclude that the largest farms are expected to continue to grow the most rapidly, and no equilibrium farm size is currently in sight. That would imply that major structural changes will likely continue in these industries, at least in the near future.

To preview our findings, growth rates in each of these four industries declined with farm size. This finding is in marked contrast to the dairy industry in which the largest farms grew faster than medium-sized farms over the same period of time. Wheat and apple industries are becoming more diversified while corn and beef industries are becoming less diversified. Within the wheat and apple industries, diversification increased faster for medium-sized farms than for the largest farms. Inferentially, these findings suggest that scale economies diminish for large farms across all four industries and, where scope economies exist, they also diminish for large farms.

Method of Analysis

We apply both inferential and statistical methods to answer the three research questions. We partition initial farms into ten non-overlapping size cohorts in 1992 based on the magnitude of agricultural sales (exclusive of government payments), with an equal number of farms in each

[1] We ascribe increased diversification as inferential evidence of scope economies. While risk aversion could also give rise to increased diversification, determining evidence of risk averse behavior in the census data is beyond the scope of this study.

cohort.[2] We track incumbent farms in the ten initial size cohorts through two successive censuses, determine differences in growth rates, levels of diversification, and industry exit rates. We also track new entrants to determine their similarity to incumbent firms.

We address the first question about whether farms are converging to an equilibrium size by examining the relationship between initial cohort size and the mean growth rate of each incumbent cohort. We conduct our analysis for the five-year period between the 1992 and 1997 censuses and for the 10-year period between the 1992 and 2002 censuses.[3] This relationship provides inferential evidence concerning whether farms are converging to an equilibrium size. Positive growth of a cohort's mean size indicates that, on average, farms in the cohort are likely operating under increasing returns to scale and/or scope. Farms in cohorts that are growing the most rapidly are likely to be among the most effective in reaping these economies.

We also examine the first question statistically by testing whether incumbent farms have grown in accordance with Gibrat's law (Sutton 1997), the mean reversion hypothesis (De Wit 2005), or a growth hypothesis consistent with evidence from the dairy industry (Skolrud *et al.* 2007). Under Gibrat's law, firms follow a random walk growth pattern. No convergence to steady-state equilibrium size occurs. Under mean reversion, larger firms grow relatively slower than smaller firms, implying that firms converge to a stable steady-state equilibrium. If, however, firms in these industries grow in ways similar to the pattern exhibited by the dairy industry (Skolrud et al. 2007), larger farms grow relatively faster than smaller farms. This would

[2] The 10% of farms with the lowest agricultural sales in 1992 were assigned to Cohort 1 and the 10% with the largest agricultural sales to Cohort 10.

[3] Since we are interested in the effect of initial firm size on growth and have data from three censuses, we examine growth rates for both a five-year and a ten-year period. We don't explicitly focus on growth rate during the second five-year period because firm sizes for incumbent cohorts overlap in the 1997 census. However, the growth rate of firms in each incumbent cohort during the second five-year period can be inferred by contrasting growth in the first five-year period with the ten-year period.

imply that farms may approach an equilibrium size, but unlike mean reversion, it would not be to a steady-state equilibrium.

To test these mutually exclusive hypotheses, two linear regressions are estimated between annual growth rates and initial farm sizes. One regression uses annual growth rates for the 1992-1997 period and the other uses annual growth rates for the 1992-2002 period. The least squares model is specified as follows:

(1) $y_{ikt} = \beta_{0t} + \beta_{1t} r_{ik} + \varepsilon_{ikt}$, $i = 1, \ldots, N_k$, t = 5-year or 10-year, k = corn, wheat, beef and apple

where y_{ikt} is the annual compound growth rate of the i^{th} farm in the k^{th} industry between the 1992 census and either the 1997 or 2002 census, r_{ik} is the initial size of farm i from industry k in the 1992 census, and ε_i is independently and identically distributed white noise. Separate equations are estimated for each commodity.

The hypothesis tests are equivalent to a t-test of the significance of β_{1t}. If not statistically significantly different from zero, the null hypothesis that cohorts grow in accordance with Gibrat's law is supported. A statistically significant negative coefficient provides support for the mean reversion hypothesis, while a statistically significant positive coefficient supports the hypothesis that cost economies are sufficiently persistent that larger farms grow relatively faster than smaller farms.

To address the questions about increasing diversification, we separate farms in each census into five sales categories. These categories differ by the percentage of the farm's total agricultural sales in its primary commodity sales category.[4] For corn and wheat farms, the sales

[4] One limitation of this approach is that, when making comparisons over time, we don't distinguish between actual diversification due to changes in production decisions and apparent diversification due to changes in relative prices of commodities. There were significant changes in relative prices over this period. For example, the relative price of

classification is based on sales of grain, oilseeds, dry beans, and dry peas; for apple farms, it is based on sales of fruit, tree nuts, and berries; and for beef farms, it is based on sales of cattle and calves.[5] The five sales categories are 90% or greater, 75-89.9%, 50-74.9%, 25-49.9%, and less than 25% of sales from the primary commodity sales category of total agricultural sales, exclusive of any government payments.

We calculate a weighted measure of specialization (the converse of diversification) for each cohort k by multiplying the share of the cohort's farms in each sales category S_{ik} by the mid-point of the sales percentile range $\bar{R}_i$ and then sum across sales categories i.

$$(2) \qquad D_k = \sum_{i=1}^{n} S_{ik} \bar{R}_i$$

This measure represents an approximation to the cohort's weighted share of total agricultural income from sales of the primary commodity group.[6] Higher percentage values indicate higher dependence on the primary commodity group's sales, greater output specialization, and lower output diversification.

Data

We use longitudinal data from the Census of Agriculture in 1992, 1997, and 2002. Based on the Census Farm Number (CFN) and Personal Operation Identification System (POIDS) codes, we track most individual farms through subsequent censuses based on the legal entity for tax purposes. Except for retired and residential/lifestyle farmers, the sample includes all farms for which the owner checked farming as his/her main occupation and had at least 100 harvested

grain to cattle was 24% higher in 1997 than in 1992. By 2002, it dropped to just 10% higher. Our assessment of the magnitude of diversification for beef in 1997 will therefore be biased upward relative to diversification for wheat and corn, particularly in 1997. However, it turns out that our qualitative conclusions are unaffected.

[5] Since the Census survey did not record revenues for our four individual commodities, we used the closest sale groups as proxies.

[6] Unlike the Herfindahl and entropy measures of diversification which use sales from several enterprises within one farm and measure spread across these several enterprises (e.g. Sumner and Wolf 2002), our measure only uses sales from the primary enterprise.

acres of corn or wheat, 5 acres of apples, or 20 beef cows, in the 1992 Census of Agriculture. The sample covers 90% of all corn acreage, 93% of wheat acreage, 95% of apple acreage, and 88% of all beef cattle and calf numbers in the nation. In this paper we use the terms wheat, corn, apple, and beef farms for inter-industry comparison. They represent all farms defined by these census criteria.

For each commodity, we rank farms in the 1992 Census of Agriculture based on their value of agricultural sales, exclusive of government payments.[7] These farms constitute our initial ten cohorts. New farm entrants in 1997 that meet the 1992 selection criteria constitute our 11th cohort, which we follow through the 2002 census. Similarly, we include new farm entrants in 2002 as our 12th cohort.[8] We compute summary statistics for each cohort in each census to determine changes in size distribution characteristics of farms over time. They include: (1) number of farms, (2) mean size, (3) median size, (4) size range, (5) size standard deviation, (6) size skewness, (7) size kurtosis, (8) number of exiting farms, and (9) portion of farms in each of the four sales categories.

To permit valid calculations of farm growth between the 1992 census and each later census, agricultural receipts are deflated by the index of prices received. Corn, wheat, apple and beef sales are deflated by the indexes of prices received for feed grains and hay, food grains, fruit and nuts, and meat animals, respectively. The remaining agricultural sales are deflated by the index of prices received for all farm products (USDA 2001, 2005).

We report the first two moments, the median and approximate range of the 1992 farm size distribution of each cohort for each commodity in Table 1. A large number of farms in each of

[7] This criterion is in addition to the value of production consumed on the farm (e.g., raised corn fed to beef cattle).
[8] For each industry, new entrants are farms we were unable to track from the previous census that now satisfy the 1992 selection criteria. A farm that was initially selected as a commodity farm remains in the sample as long as it continues as a legal business entity and produces the commodity (even if it no longer meets the initial selection criteria).

the four industries were relatively small operations, selling less than $100,000 worth of agricultural commodities. While less than half of all corn and wheat farms can be considered small operations, half of apple farms and 70% of beef farms fell into this category. For all commodities, cohorts 1-9 had medians that were very similar to their means, and they had small standard deviations. In each case, the standard deviation for cohort 10 was much larger than the others because its range was open-ended. The median and mean values for cohort 10 were also very different for each commodity, suggesting that this cohort was right-skewed, containing some very large farms.

We also report the median, and range width of the 1997 and 2002 farm size distributions for each incumbent cohort in Table 2. Medians were substantially different than the means in all cohorts for each commodity. The standard deviations were also large and many increased over time. Along with the range width, these statistics indicate that the size distribution of farms in each incumbent cohort became highly asymmetric and dispersed over time. For each of the first nine cohorts, size heterogeneity of farms increased over time because a few farms experienced substantial growth. In fact, except for apples, a number of farms in every cohort grew enough to be within the range of the largest cohort in successive censuses.

Results

Firm Growth

Corn and wheat farms grew less rapidly than apple and beef farms (See Figure 2). However, farms did not maintain a constant growth rate over the ten-year period in any of the industries. In general, farms grew less rapidly between 1997 and 2002 than between 1992 and 1997, making the 10-year average growth rate lower than the 5-year average growth rate. The growth rates for incumbent apple and beef farms slowed the most between 1997 and 2002.

The growth rate distribution across cohorts was very similar for corn, wheat, and beef farms. The most rapid growth occurred in the smallest cohort, and the slowest growth occurred in the largest cohort (see Figure 3). This pattern applied to both time intervals. Additionally, as noted above, the magnitude of growth rates decreased for all cohorts for each of the three commodities over the ten-year period relative to the five-year period.

Despite having some similarities to the growth rate patterns of the other three commodities, farms in the apple industry followed a different path, with most of the differences occurring at the upper end of the farm size distribution. In particular, the largest farms did not grow the slowest in this industry. Instead, farms in cohort 7, for example, grew more slowly than those in cohort 10 in both periods.

For all commodities, the growth rate was strongly and negatively correlated with cohort number over both periods. With the exception of the apple cohorts, all cohorts grew at a more rapid rate than the next larger cohort over each time interval. Correlation coefficients between the growth rate and the cohort number ranged from -0.85 to -0.93 for corn, wheat, and beef farms in both the five and ten year periods. Although a little lower (approximately -0.70), the correlation coefficients for the apple industry were also negative for each period.

The estimated parameters for equation (1) are reported in Table 3 for each commodity and time interval. The parameter estimate associated with the annual growth rates for each time interval was negative for each commodity. With the exception of the wheat and apple equations for the ten-year period, the growth parameter estimate was significant at the 5% level. Thus, we fail to reject the hypothesis of mean reversion for either time interval for corn and beef and for the five-year period for wheat and apples. Additionally, we fail to reject the hypothesis of

random walk growth implied by Gibrat's law for the ten-year time interval for both wheat and apple farms.

Based on our findings from the cohort growth patterns and the statistical tests for all four commodities, we can answer the first question and provide inference about equilibrium size in each industry. First, they show the mean size of the largest cohort grew less rapidly over the 5-year and 10-year periods than the mean size of nearly all other cohorts. We therefore conclude that the answer to the first question is "No": the largest farms do not grow as rapidly as medium-sized farms. Second, they provide evidence for all commodities in the five-year period and for corn and beef in the ten-year period that cost economies diminish with size and suggest that a stable steady-state equilibrium does exist. Only in the case of wheat and apples for the ten-year period do the size distributions appear to follow a random walk with no stable steady-state equilibrium. Thus, we can clearly rule out the hypothesis that "larger farms grow relatively faster than smaller farms" for all four industries. We also find considerable evidence to support the hypothesis that a steady-state equilibrium exists for two of these four industries (corn and beef) but the support is dependent on time interval for wheat and apples.

Firm Size and Diversification

Farms in the sample varied greatly by the percent of agricultural income generated by the respective commodity group. Recall that we use the commodity group's weighted share of agricultural income, D_k, from equation (2) as a proxy for specialization, i.e., the converse of diversification. Specialization differences are examined both among cohorts and between time intervals, the results of which are summarized in Table 4

Apple farms were the most specialized in each census while beef farms were generally the least specialized. On average, our sample of apple farms generated about 80% of their

agricultural revenue from the sale of fruit, tree nuts, and berries in 1992 while beef farms received only 44% of their agricultural revenue from the sale of cattle and calves. Grain farms received 63-65% of their agricultural revenue from the sale of grains, oilseeds, dry beans, and dry peas in 1992. Over the ten-year period, both wheat and apple farms became less specialized while corn and beef farms became more specialized in their source of agricultural revenues.[9]

In addition, the level of specialization varied by cohort level. In 1992, the 10th cohort (containing the largest farms) was the least specialized for each of the four commodities. It remained the least specialized in each census for all commodities except apples. The most specialized cohort, however, varied by commodity and census. For corn and beef, it was generally one of the smaller cohorts; for wheat and apples, it was generally one of the mid-sized cohorts.

The relationship between farm size and the degree to which the farm relied on its primary output is also apparent from the correlation coefficients. In the case of grain and beef farms, the generally large negative correlation coefficients document a clear tendency among these farms toward less specialization as farm size increases. This tendency became stronger over time for beef but weaker for grain, especially wheat for which the correlation coefficient approached zero in 2002. For apple farms, the positive correlation in 1997 and 2002 indicates a tendency toward more specialization as farm size increases.

Our findings concerning temporal changes in specialization for the four industries answer the second research question, Do farms become more diversified over time? They show that only wheat and apple farms become more diversified over time. We therefore conclude that the

[9] The results in Table 4 indicate that beef farms became much more specialized in 2002. However, the survey questions that defined degree of specialization changed for beef farms in the 2002 Census of Agriculture. Consequently, our conclusion about beef farms is subject to the possibility of measurement error due to the change in the way the questions were formulated. There was little change in level of specialization on beef farms between the 1992 and 1997 censuses.

answer to the second question is "Yes" for wheat and apples, but "No" for the corn and beef industries.

Consequently, the third question, whether larger farms diversify more rapidly than medium-sized farms, only applies to wheat and apple farms since corn and beef farms became more specialized. In order to answer this question, we first organized cohorts into small, medium and large farm groups. We classified farms in cohorts with less than approximately $100,000 in 1992 agricultural sales as small farms, those with $100,000 - $300,000 in sales as medium-sized farms, and those with sales above $300,000 in sales as large farms. The cohorts which fall into each class are reported in Table 5. We then used the medium and large farms' specialization indices to compute rates of change in specialization coefficient over time (see Table 4). In each case, the relative decrease in specialization (when it occurred) was less for large farms than for medium-sized farms. Thus, larger farms do not appear to diversify more rapidly than medium-sized farms for either wheat or apple farms.

Firm Entry and Exit

The distribution of new entrants was very different than the distribution of incumbent farms and varied between censuses (see Table 6). Their mean size was larger than the average incumbent, falling between the means of incumbent cohorts 6 and 8 in 1997 and cohorts 6 and 10 in 2002. Relative to other farms, new apple entrants had the largest mean size relative to the incumbents, falling between the means of apple incumbent cohorts 7 and 8 in 1997 and cohorts 9 and 10 in 2002.[10]

The distribution of new entrants was positively (right) skewed, so their median size was much smaller that their mean in all industries. These statistics indicate that a small number of

[10] We do not have comparable data for farms that exit since we only observe their sales in the last census before they exit. Also, we did not track their sales separately from the cohort's incumbents.

entrants were very large. In fact, in 1997 their median size was smaller than the overall median size of all incumbent farms in the corresponding industry, falling between the median sizes of incumbent cohorts 3 and 4. The median size of 2002 new entrants was closer to the overall median size of all incumbent farms, falling between cohorts 4 and 7.

Between the 1992 and 1997 censuses, more new farms entered each industry than exited. Only small grain and medium-sized apple farms had approximately the same number of entering and exiting farms. The correlations between the exit/entry ratio and cohort number were highly negative for corn and wheat, close to zero for apples, and positive for beef (Table 7).

Over the 10-year period, with the exception of small beef operations and large corn farms, there were more exiting than entering farms of all sizes in each industry. This imbalance was most apparent for wheat farms – more than four times as many farms exited wheat production as entered this industry. Also, more than twice as many large beef farms exited the industry as entered. The correlations between exit/entry ratio and cohort number suggest that the number of exiting farms relative to the entering farms decreases with size in the corn and wheat industries, but increases with size in the beef industry.

Additionally, new entrants between 1992 and 1997 were more specialized than were all incumbents (see Table 4). With the exception of beef, at least 70% of total agricultural sales came from the sale of the primary commodity. Apple entrants were the most specialized and beef entrants were the least specialized in 1997 with 85% and 51% of their total agricultural income coming from the sale of the primary commodity, respectively. Corn, wheat, and apple entrants in 1997 became less specialized by the 2002 census. New entrants in the apple industry between 1997 and 2002 were also the most specialized among the four industries and were more

specialized than any incumbent apple cohort. New entrants to the other industries were also more specialized than nearly all incumbent cohorts.

Inter-Industry Context

Our findings with regard to farm growth and diversification for corn, wheat, apple, and beef industries provide important counter examples to those found for the dairy industry (Skolrud et al. 2007). The similarities in structural changes previously observed at the industry level for many agricultural commodities (Gray and Boehlje 2007; Morrison-Paul et al. 2004; Mafoua 2002) do not appear to hold at the farm level. Our inferential evidence of scale and scope economies was considerably different between these industries and the dairy industry.

Scale economies diminished with size for each of the four industries while they increased with size for dairy farms. Large dairy farms grew faster than medium-sized farms while large grain, apple, and beef farms grew more slowly than medium-sized farms. This suggests that, unlike dairies, the size of farms in some of these industries is approaching an equilibrium and this equilibrium is generally stable.

The extent of scope economies also varied substantially among industries. Scope economies were evident in the dairy industry as farms of all sizes became much more diversified. Our findings suggest that the corn and beef industries did not exhibit evidence of scope economies while the wheat and apple industries did. Like the dairy industry, the evidence of scope economies in the wheat and apple industries was greater for medium-sized than for large farms.

Conclusions

The purpose of this study was to assess evidence of scale and scope economies for four major agricultural industries using longitudinal agricultural census data between 1992 and 2002. They have become more consolidated as the total number of farms decreased while the number of

large farms producing each commodity increased in each of these industries. Consequently, production has become more concentrated in each industry.

We conclude that scale economies diminish with size for each of these four industries. Large corn, wheat, apple, and beef farms all grew slower than medium-sized and small farms. This suggests that their size distribution is approaching a steady-state equilibrium. This statement holds inferentially for all four commodities. However, based on our statistical hypothesis tests, only the size distribution of corn and beef farms is approaching a steady state equilibrium while the others are following a random walk. In each industry, new entrants were larger on average than the incumbents, but the size of new entrants showed high variability.

Also, based on evidence that it became more specialized over time, we conclude that the corn industry does not exhibit scope economies. Scope economies were apparent in the apple industry and to a lesser extent in the wheat industry. They were greater for larger than for medium-sized farms. A growing number of apple and wheat producers are making the strategic decision of becoming less dependent on production of fruit and grain, respectively, in favor of other agricultural outputs. Large farms remain less specialized than medium-sized farms. However, the rate of diversification over time was highest among medium-sized producers. Small farms in all four industries remained more specialized than larger farms.

There were more exits than new entrants in all industries over the ten-year period from 1992 to 2002, particularly evident in the wheat industry. The relationship between industry exit/entry ratio and farm size, however, was industry specific. The ratio increased with size in the beef industry while it decreased with size in the corn and wheat industries. In the apple industry, there was no apparent relationship between industry exit/entry ratio and farm size.

These findings have important decision-making implications for producers of these commodities. The diminishing scale economies in these four industries suggest that larger producers might avoid diseconomies of scale and reduce potential inefficient production by approaching expansion cautiously. The dominance of scope economies over scale economies for large apple and wheat farms suggests that large farmers in these two industries could grow more efficiently by pursuing output diversification. Alternatively, corn producers of all sizes have little incentive to pursue greater diversification given their current technologies.

These findings also have important decision-making implications for policy makers, but implications of a rather benign nature. Unlike the dairy industry in which policy intervention may ultimately be needed to promote competitiveness because the largest farms are growing at the fastest rate, the evidence suggests little need for such policies in these industries.

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Table 1: Agricultural sales range, median, and sample distribution moments for cohorts, 1992, in $1,000 [a]

Cohort	Corn			Wheat			Apples			Beef		
	Median	Mean	Range	Median	Mean	Range	Median	Mean	Range	Median	Mean	Range
1	43	41 *(12)*	<54	19	19 (8)	<29	5	5 *(3)*	<11	5	5 *(2)*	<8
2	69	73 *(7)*	54-77	39	39 (6)	29-48	18	18 *(5)*	11-26	10	10 *(2)*	8-13
3	92	97 *(7)*	77-100	59	58 (7)	48-69	35	34 *(6)*	26-45	16	16 *(2)*	13-20
4	115	122 *(8)*	100-125	81	81 (7)	69-93	58	57 *(8)*	45-70	24	24 *(3)*	20-30
5	141	142 *(9)*	125-153	106	107 (8)	93-121	85	88 *(11)*	70-107	36	36 *(4)*	30-44
6	173	173 *(10)*	153-187	139	139 (11)	121-158	127	128 *(13)*	107-150	53	54 *(7)*	44-65
7	212	213 *(14)*	187-234	182	183 (15)	158-210	183	183 *(19)*	150-216	79	79 *(10)*	65-96
8	268	269 *(20)*	234-303	247	248 (23)	210-291	270	271 *(34)*	216-334	117	118 *(15)*	96-146
9	362	366 *(40)*	303-444	358	364 *(48)*	291-462	427	439 *(72)*	334-585	188	192 *(32)*	146-256
10	625	938 *(1,737)*	>444	683	1,094 *(2,282)*	>462	950	1,552 *(1,762)*	>585	404	651 *(2,330)*	>256

[a] Standard deviations are in parentheses. Data source: *Census of Agriculture* (USDA 1992)

Table 2: Agricultural nominal sales range, median, and sample distribution moments for incumbent cohorts, 1997 and 2002, in $1,000[a]

Cohort	Corn			Wheat			Apples			Beef		
	Median	Mean	Range Width	Median	Mean	Range Width	Median	Mean	Range Width	Median	Mean	Range Width
1997 Census												
1	63	87*(159)*	8,775	28	43*(88)*	3,500	9	22*(41)*	270	7	16*(88)*	6,154
2	90	111*(112)*	3,158	48	66*(182)*	11,422	18	32*(54)*	584	11	18*(59)*	3,050
3	113	136*(130)*	4,024	70	88*(91)*	1,905	35	49*(57)*	440	15	25*(102)*	7,641
4	139	160*(146)*	6,225	95	117*(172)*	10,475	60	92*(217)*	3,863	22	32*(73)*	3,500
5	167	188*(137)*	2,585	122	144*(160)*	6,711	93	116*(135)*	1,668	34	47*(100)*	5,469
6	200	223*(170)*	4,000	158	182*(146)*	2,712	125	155*(134)*	1,273	51	67*(156)*	13,355
7	241	264*(174)*	4,525	202	229*(170)*	4,112	175	215*(222)*	2,804	78	94*(106)*	4,024
8	300	330*(246)*	9,223	270	302*(238)*	9,224	248	308*(277)*	3,470	117	135*(129)*	5,388
9	394	428*(264)*	7,016	383	431*(348)*	15,664	440	606*(1,778)*	38,668	188	214*(180)*	4,003
10	684	1,022*(2,306)*	115,885	743	1,197*(2,667)*	105,417	1,102	1,897*(2,919)*	32,563	408	659*(1,912)*	120,842
2002 Census												
1	56	92(192)	7,322	21	44(153)	5,872	15	35(68)	507	7	18(96)	4,421
2	77	110(151)	4,046	40	62(88)	1,237	22	36(63)	724	10	23(139)	7,484
3	96	131(186)	5,076	59	88(134)	2,817	31	46(50)	272	15	28(85)	2,905
4	118	158(261)	14,729	82	110(136)	3,074	60	88(152)	1,954	21	36(99)	3,000
5	146	187(249)	9,264	107	139(200)	5,498	78	106(134)	1,009	31	51(179)	11,260
6	175	216(244)	7,844	139	175(218)	9,264	133	171(196)	2,109	47	69(130)	5,943
7	214	258(273)	9,953	179	220(218)	3,600	146	187(178)	1,294	71	94(117)	2,149
8	268	322(338)	12,830	236	291(369)	11,102	252	314(315)	2,774	106	135(151)	3,020
9	351	416(386)	8,878	339	409(452)	15,713	396	488(453)	3,850	167	208(226)	4,997
10	608	961(2,085)	108,248	633	1,126(3,340)	138,600	943	1,670(2,039)	11,255	366	587(1,741)	124,174

[a] Standard deviations are in parentheses. Data source: *Census of Agriculture* (USDA 1997, 2002)

Table 3: Growth rate coefficient estimates, equation (1) [a]

	Corn		Wheat		Apples		Beef	
Variable	5-year	10-year	5-year	10-year	5-year	10-year	5-year	10-year
Constant	2.30**	-0.06	2.63**	-1.06**	2.15**	-0.11	2.38**	-0.88**
	(0.05)	(0.05)	(0.07)	(0.09)	(0.50)	(0.35)	(0.07)	(0.06)
r_i	-0.002**	-0.0007**	-0.001**	-0.0001	-0.002**	-0.0009	-0.001**	-0.001**
	(0.0001)	(0.00009)	(0.0001)	(0.0001)	(0.0007)	(0.0005)	(0.0001)	(0.0001)

[a] Standard errors are in parentheses. Estimated parameters that are significant at the 0.05 level are marked with an asterisk and those significant at the 0.01 level are marked with two asterisks.

Table 4: Specialization coefficients for incumbent and new entrant cohorts, estimated at the cohort means

	Corn			Wheat			Apples			Beef		
Cohorts	1992	1997	2002	1992	1997	2002	1992	1997	2002	1992	1997	2002
1	0.79	0.77	0.72	0.77	0.69	0.55	0.78	0.73	0.77	0.47	0.47	0.75
2	0.75	0.76	0.74	0.69	0.67	0.57	0.81	0.74	0.71	0.49	0.49	0.75
3	0.71	0.76	0.74	0.68	0.67	0.60	0.81	0.74	0.71	0.50	0.49	0.74
4	0.67	0.73	0.72	0.67	0.69	0.62	0.82	0.76	0.74	0.50	0.48	0.71
5	0.64	0.71	0.71	0.68	0.70	0.63	0.84	0.80	0.78	0.48	0.46	0.66
6	0.62	0.69	0.70	0.68	0.70	0.65	0.84	0.81	0.77	0.44	0.43	0.61
7	0.59	0.66	0.68	0.66	0.70	0.66	0.84	0.80	0.80	0.41	0.40	0.55
8	0.57	0.64	0.66	0.63	0.66	0.64	0.83	0.80	0.78	0.38	0.37	0.49
9	0.54	0.61	0.63	0.58	0.62	0.61	0.82	0.81	0.80	0.36	0.34	0.44
10	0.42	0.50	0.52	0.42	0.48	0.47	0.76	0.76	0.75	0.35	0.33	0.39
11		0.78	0.75		0.71	0.60		0.85	0.80		0.51	0.74
12			0.71			0.70			0.82			0.74
Avg All Cohorts	0.63	0.68	0.68	0.65	0.66	0.60	0.81	0.77	0.76	0.44	0.43	0.61
Avg Medium Cohorts				0.66	0.69	0.65	0.83	0.80	0.78			
Avg. Large Cohorts				0.50	0.55	0.54	0.79	0.78	0.77			
Least Specialized	10	10	10	10	10	10	10	1	2-3	10	10	10
Most Specialized	1	1	2-3	1	5-7	7	5-7	6,9	7,9	3-4	2-3	1-2
Correlation Coefficient	*-0.98*	*-0.94*	*-0.85*	*-0.84*	*-0.61*	*-0.02*	*0.01*	*0.69*	*0.56*	*-0.90*	*-0.93*	*-0.98*

Table 5: Cohort numbers in farm size classes

	Corn	Wheat	Apples	Beef
Small farms	**1-3**	**1-4**	**1-5**	**1-7**
Medium-sized farms	**4-8**	**5-8**	**6-8**	**8-9**
Large farms	**9-10**	**9-10**	**9-10**	**10**

Table 6: Agricultural sales range, median, and sample distribution moments for new entrants, in $1,000[a]

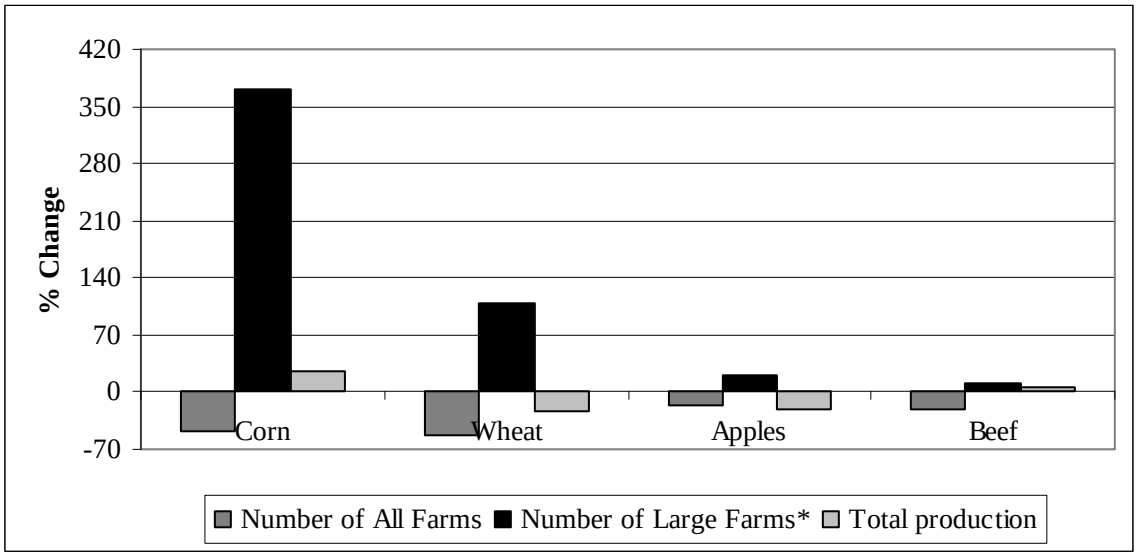
Cohort	Corn			Wheat			Apples			Beef		
	Median	Mean	Range	Median	Mean	Range Width	Median	Mean	Range Width	Median	Mean	Range Width
11 (1997)	125	245*(1,383)*	81,799	77	199*(993)*	35,827	37	253*(1,273)*	18,854	17	75*(682)*	81,805
11 (2002)	119	236*(605)*	15,513	174	428*(1,626)*	69,594	44	150*(300)*	1,961	17	81*(433)*	26,559
12 (2002)	200	401*(1,212)*	70,797	83	205*(885)*	29,584	120	676*(3,432)*	69,596	25	131*(596)*	43,817

[a] Standard deviations are in parentheses. Data source: Agricultural Census, (USDA, 1992)

Table 7: Ratio of exits to new entrants

Size	Corn		Wheat		Apples		Beef	
	5-Year	10-Year	5-Year	10-Year	5-Year	10-Year	5-Year	10-Year
Small	1.1	1.5	1.1	4.1	0.7	1.3	0.5	0.8
Medium	0.8	1.7	0.9	4.6	1.0	1.5	0.8	1.2
Large	0.6	1.0	0.7	3.4	0.6	1.2	0.4	2.4
Correlation Coefficient	*-0.91*	*-0.59*	*-0.95*	*-0.20*	*0.07*	*0.03*	*0.66*	*0.74*

Figure 1: Percentage change in the number of all farms, number of large census farms, and total production (1987-2002)



* Large census farms are those with at least 1,000 acres of corn or wheat, 500 acres of apples, or 500 head of beef cows.

Figure 2: Annualized average growth rates

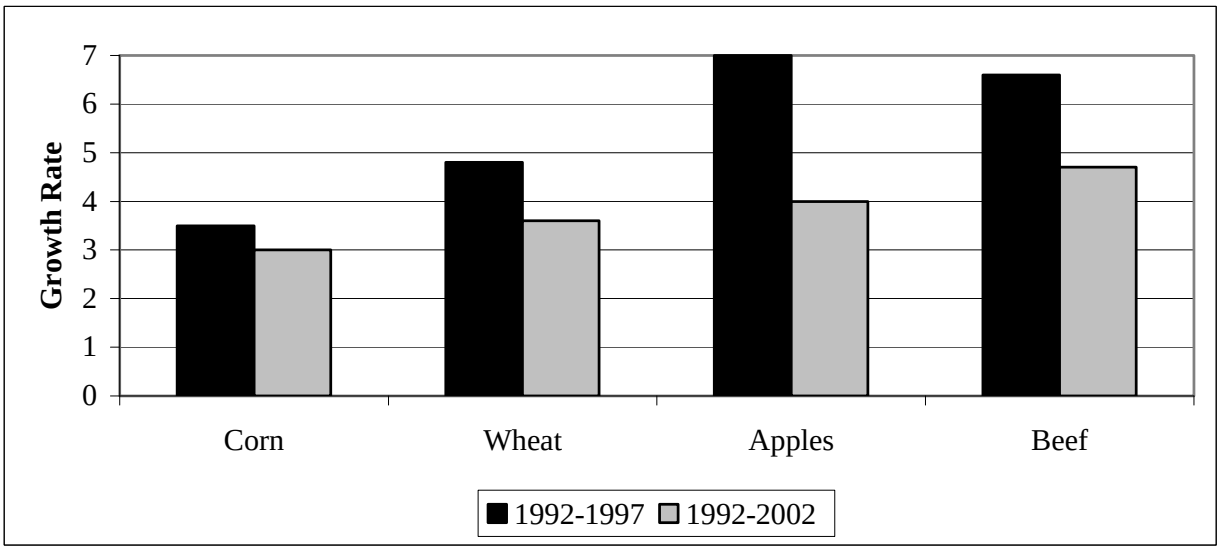


Figure 3: Annual growth rates